

# Randomized Block Design and Covariance Design

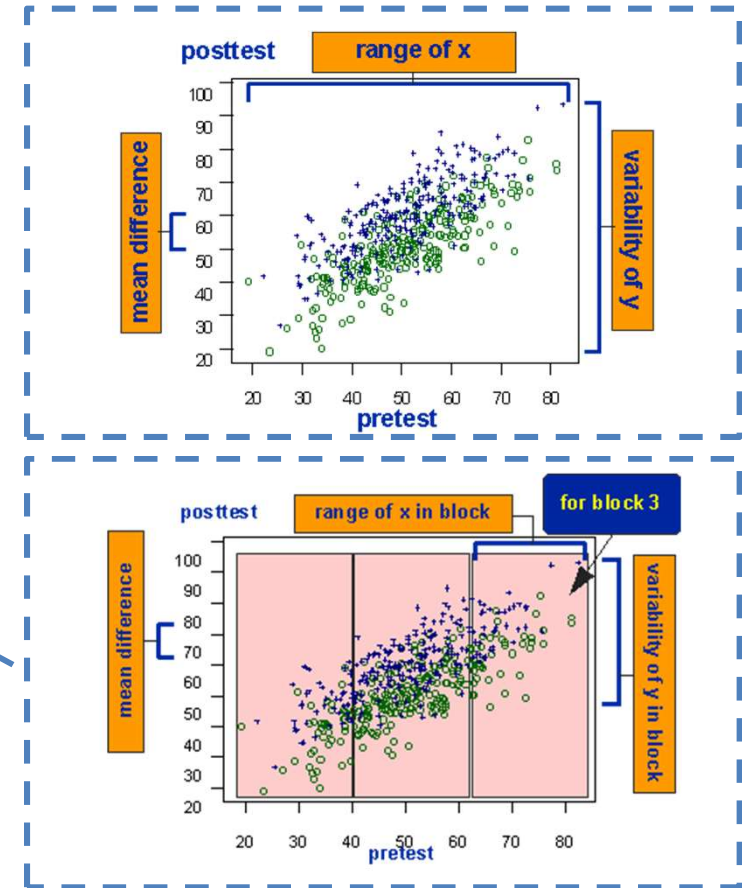
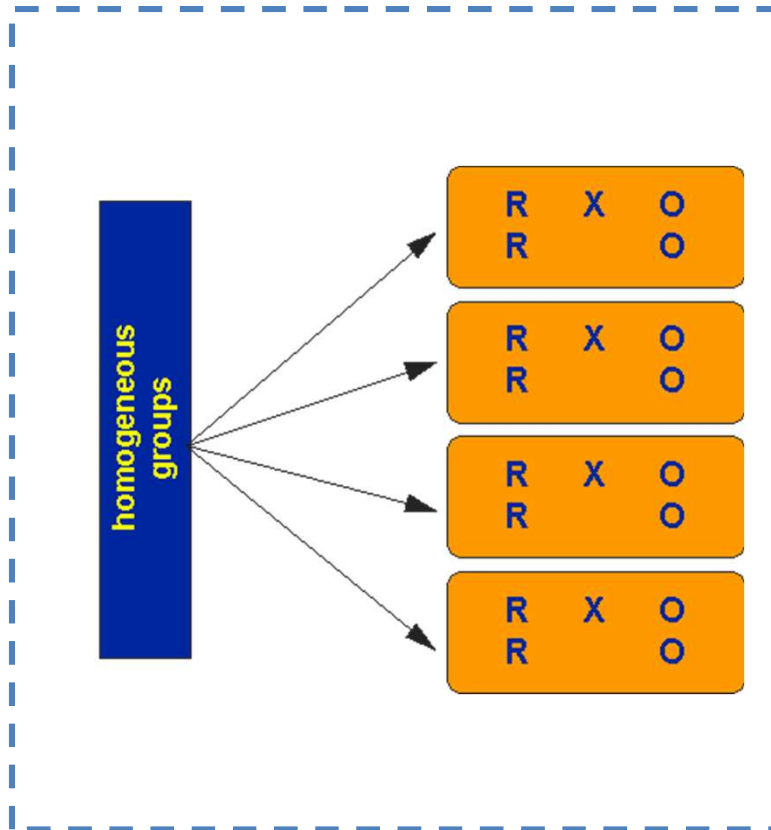
Illustration

based on simulated data

# Basic idea

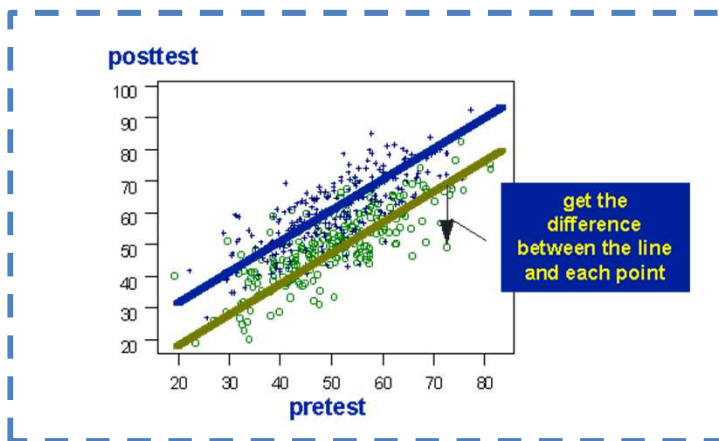
- Error variance (noise) reduced by blocking the data (blocks are more homogeneous than entire data set; similarity to stratified sampling).
- Blocks based on other information (e.g. gender, pre-test, etc.)
- Design issue because we must include the variable that informs block formation.

# Randomized Block Design

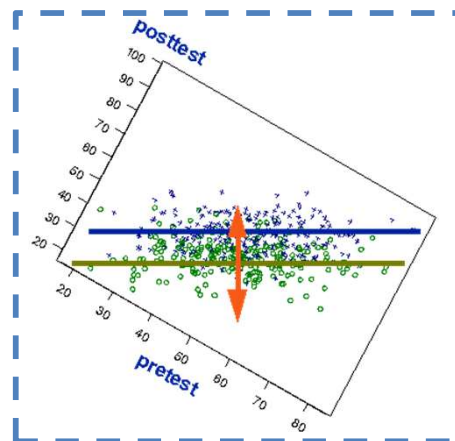


# Covariance Design

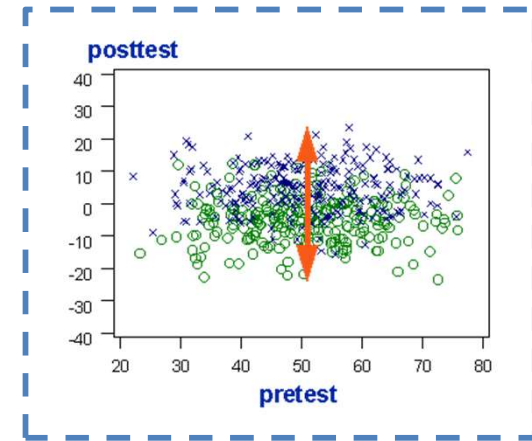
- Covariate explains part of the variance, which would otherwise be treated as *error variance* (residual/unexplained variance)



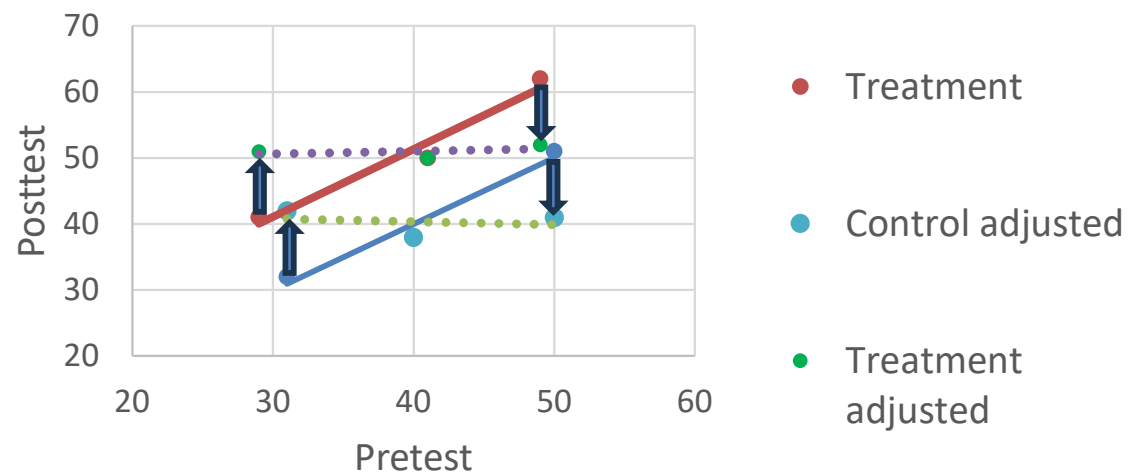
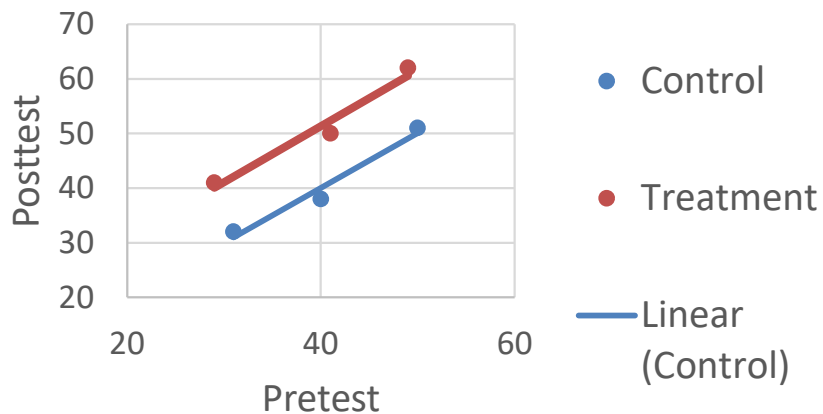
Pretest Posttest



Pretest Posttest



● Control



# Simulated data

- Treatment (n=60) and control group (n=60)
- Pre-test, post-test
  - pre-test score is used as the blocking variable
- Treatment group performs higher on post test

# Simulated data

- id: person id
- group:
  - 1 treatment
  - 2 control
- pre\_test:
  - pre-test score
- post\_test:
  - post-test score
- block:
  - 1/2/3 according to pre-test (33%/67%)

\*rand\_block\_design.sav [DataSet1] - SPSS Statistics Data Editor

	id	group	pre_test	post_test	block
1	1	1	71,20	68,99	3
2	2	1	69,39	88,67	3
3	3	1	27,71	52,94	1
4	4	1	85,22	81,34	3
5	5	1	59,61	72,42	3
6	6	1	36,71	36,27	1
7	7	1	47,79	52,88	2
8	8	1	72,76	62,90	3
9	9	1	70,74	60,32	3
10	10	1	7,48	9,32	1
11	11	1	84,20	95,05	3
12	12	1	41,13	52,99	2
13	13	1	59,25	70,95	3
14	14	1	48,38	59,03	2
15	15	1	21,91	22,55	1
16	16	1	67,41	78,69	3
17	17	1	40,49	57,40	2
18	18	1	31,93	43,22	1
19	19	1	10,23	22,28	1
20	20	1	65,26	68,08	3
21	21	1	41,79	51,40	2

# T-test (No blocking)

- Simple comparison of groups using t-test
  - $p=0.058$

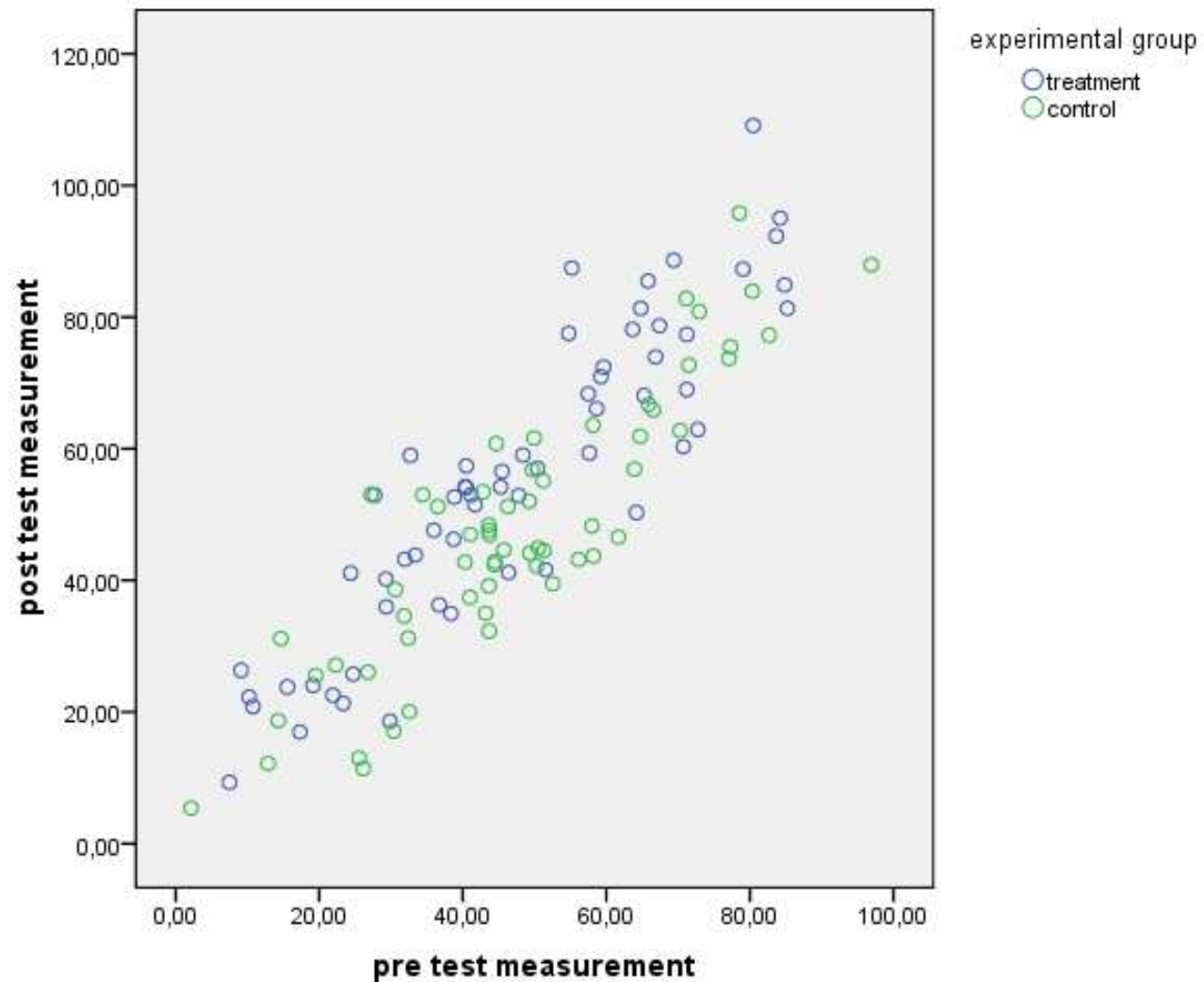
Group Statistics

group experimental group		N	Mean	Std. Deviation	Std. Error Mean
post_test post test measurement	1 treatment	60	55,4145	23,08291	2,97999
	2 control	60	47,8627	20,06111	2,58988

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference		
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
post_test post test measurement	Equal variances assumed	1,832	,178	1,913	118	,058	7,55182	3,94814	-,26658	15,37021
	Equal variances not assumed			1,913	115,751	,058	7,55182	3,94814	-,26815	15,37178

# Pre-test post-test scatterplot





# No difference at pre-test

**Group Statistics**

group experimental group		N	Mean	Std. Deviation	Std. Error Mean
pre_test pre test measurement	1 treatment	60	47,3232	21,36585	2,75832
	2 control	60	47,6387	19,41239	2,50613

**Independent Samples Test**

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
pre_test pre test measurement	Equal variances assumed	1,842	,177	-,085	118	,933	-,31546	3,72680	-7,69553	7,06461
	Equal variances not assumed			-,085	116,932	,933	-,31546	3,72680	-7,69623	7,06531

# Participants blocked based on pre-test

- Anova without blocking:
- $p=0.058$  (see also t-test)

**Tests of Between-Subjects Effects**

Dependent Variable: post test post test measurement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1710,898 <sup>a</sup>	1	1710,898	3,659	,058
Intercept	319985,085	1	319985,085	684,263	,000
group	1710,898	1	1710,898	3,659	,058
Error	55180,860	118	467,634		
Total	376876,843	120			
Corrected Total	56891,758	119			

a. R Squared = .030 (Adjusted R Squared = .022)

- Anova with blocking:
- $p=0.001$
- sum of squares block and block\*group plus error approximately equal sum of squares error in Anova above

**Tests of Between-Subjects Effects**

Dependent Variable: post test post test measurement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	38533,593 <sup>a</sup>	5	7706,719	47,857	,000
Intercept	312197,734	1	312197,734	1938,676	,000
group	1998,392	1	1998,392	12,410	,001
block	35796,437	2	17898,219	111,144	,000
group * block	166,832	2	83,416	,518	,597
Error	18358,166	114	161,037		
Total	376876,843	120			
Corrected Total	56891,758	119			

a. R Squared = .677 (Adjusted R Squared = .663)

# Analysis Using Regression

- 2 dummy variables for blocks
  - block 1 0/0
  - block 2: 1/0
  - block 3: 0/1
- Group
  - Treatment 1
  - Control 0

- Effect for treatment:
- $p=0.001$
- As in Anova

Coefficients<sup>a</sup>

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	26,136	2,410		10,843	,000
	group01	8,249	2,345	,189	3,518	,001
	dummy1	21,314	2,864	,461	7,441	,000
	dummy2	42,820	2,826	,927	15,150	,000

a. Dependent Variable: post\_test post test measurement

# Pre-test as a covariate

- Pre-test is continuous variable
- Blocking uses information on pre-test relative to simple t-test
- But blocking means loss of information relative to covariance design
- Use of pre-test as a covariate

- ANCOVA:
- Further reduction of sum of squares error
- $p=0.000...$

Tests of Between-Subjects Effects

Dependent Variable: post test post test measurement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	46221,832 <sup>a</sup>	2	23110,916	253,420	,000
Intercept	770,575	1	770,575	8,450	,004
pre_test	44510,934	1	44510,934	488,080	,000
group	1849,490	1	1849,490	20,280	,000
Error	10669,926	117	91,196		
Total	376876,843	120			
Corrected Total	56891,758	119			

a. R Squared = .812 (Adjusted R Squared = .809)